



LMR Replacement Cost Study Report

Final Document

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1. OVERVIEW

This cost study was performed to estimate the replacement value of the Nation's public safety land mobile radio (LMR) equipment and infrastructure. Commissioned as part of the ongoing efforts of the Public Safety Wireless Network (PSWN) program, the study represents the first known comprehensive effort to estimate the replacement value of the LMR communications infrastructure currently installed and used by public safety agencies of local state, and federal governments.

The results of this study will enable the public safety wireless communications infrastructure to be compared with other critical infrastructures, such as transportation or electrical power systems. Additionally, as the administration, Congress, the National Telecommunications and Information Agency (NTIA), and the Federal Communications Commission (FCC) consider policies or standards regarding LMR communications, this estimate can serve as a baseline to gauge the fiscal impact of key decisions.

1.1 Replacement Value Defined

For the purpose of this study, "replacement value" was defined as the 1998 cost to replace a piece of equipment with one that is similar in both function and features. The use of replacement values normalizes costs across all agencies regardless of actual acquisition costs, thus enabling comparisons of systems purchased in different years. It also establishes a baseline to which future systems can be compared. Replacement values used in this study do not include testing, installation, training, documentation, operation and maintenance, or other lifecycle costs.

1.2 Strategy

The strategy for estimating this value was systematically developed to ensure consistency across the diverse public safety community. First, a comprehensive survey effort collected equipment information from agencies. Second, independent research determined the replacement value for each type of equipment by gathering and analyzing prices across multiple vendors. Finally, a cost model was developed to calculate the overall replacement value by combining the cost data with equipment data from survey respondents.

The methodology for performing this study is described in the Cost Study Methodology Report, dated February 4, 1998. The methodology report is being updated to provide a detail accounting of the complete approach used to arrive at the replacement values reported in this document.

1.2.1 Development of the Equipment Survey

Surveys were designed to collect equipment inventory data consistently across many different agencies. Accurate accounting was essential because quantity is such a significant determinant of infrastructure value. Survey questions also distinguished between levels of sophistication and features within a particular equipment type. This enabled more specific application of replacement values within each survey response.

The survey included both user and network equipment that would generally be used in any given public safety LMR system. Table 1 lists the hardware included in the study.

Table 1
LMR Equipment Included in Survey

User Equipment	Network Equipment	Miscellaneous Equipment
Portable Radios Mobile Radios Mobile Data Terminals Mobile Data Computers	Base Stations Repeaters Satellite Receivers Antenna Towers VSATs Microwave Links Dispatch Consoles Desktop Controllers Control Center Systems Receiver Combiners Duplexers	Remote/Collar Microphones Earpieces Headsets Battery Chargers Dialup Modems Pagers Recorders Spare Antennas and Batteries

This study encompassed only equipment currently *owned* by agencies. Although lease arrangements or commercial services could represent a significant financial investment, the replacement value methodology considered only equipment that generally would be acquired through capital means.

1.2.2 Targeted Survey Population

The study targeted all public safety agencies in the United States. Because of the distinct nature of local, state, and federal agencies, three separate survey tools were administered. Although the format of these tools varied, the basic content was consistent throughout.

The survey strategy for each level of government differed as well. Federal entities, relatively few in number, were polled through a census methodology. Federal departments and agencies traditionally considered as first responders to emergency situations or providers of other public safety services, most of which participate in the Federal Law Enforcement Wireless Users Group (FLEWUG), received a survey. Because the response rate was 100 percent, calculating the results required no projections. Table 2 lists the federal departments and agencies surveyed.

Table 2
Federal Agencies Surveyed

Department of Justice	Federal Bureau of Investigation Federal Bureau of Prisons Drug Enforcement Agency Immigration and Naturalization Service U.S. Marshals Service Inspector General
Department of the Treasury	Bureau of Alcohol, Tobacco and Firearms Bureau of Engraving and Printing Federal Law Enforcement Training Center Internal Revenue Service U.S. Customs Service U.S. Mint U.S. Secret Service
Department of Commerce	National Oceanic & Atmospheric Administration National Maritime Fisheries Service National Ocean Service National Institute of Standards and Technology Environmental Research Laboratory The Bureau of the Census
Department of Agriculture	Forest Service Animal & Plant Health Inspection Service National Resources Stabilization & Conservation Service
Department of the Interior	Bureau of Indian Affairs Bureau of Land Management Bureau of Reclamation Fish and Wildlife Service National Park Service U.S. Geological Survey
Department of Transportation	U.S. Coast Guard
Independent Agencies	Federal Emergency Management Agency

The survey population of state public safety agencies was established through research on each state's organizational structure and phone contacts with agencies. To attain statistically reliable results, every agency ascertained as having a public safety-related mission *and* a radio presence was sent a survey. In some cases, a central department was identified that could provide equipment information for all relevant agencies in that state. Agencies were categorized by type, and each state received at least one survey. The 7 states having a Radio/IT office were only sent one survey which was completed for all agency inventories in the state. Table 3 shows the breakdown of state agencies and the corresponding response rate.

Table 3
State Agencies Surveyed

<i>Agency Type</i>	<i>Population</i>	<i>Responses</i>	<i>Response Rate</i>
Corrections	42	24	57.8%
Emergency Management	38	14	36.8%
State Police	46	24	52.2%
Fire Marshal	7	7	100.0%
Medical Services	3	3	100.0%
Radio/IT	7	7	100.0%
Miscellaneous Public Safety	18	15	83.3%
Total	161	94	58.4%

Using the cost model, values were calculated for each survey response, then averaged by category. Total category values were derived by multiplying the averages by the total number of agencies in the respective categories. Adding the category values produced the overall state value. The survey methodology and response rate resulted in a 95.0 percent confidence level for the estimated LMR replacement value for state public safety agencies.

Local public safety agencies, the most abundant nationwide, were surveyed through a stratified random sample. A population of 51,835 agencies was established through the use of the *1997 National Directory of Fire Chiefs and Emergency Departments* and the *1996 National Directory of Law Enforcement Administrators*, both compiled by the National Public Safety Information Bureau (NPSIB). Agencies were stratified by the geographic region, population, and Metropolitan Statistical Area status of their respective counties (unlike state agencies, local agencies were *not* categorized by function). These local groups were then sampled in proportion to the population of agencies. Table 4 details the local public safety agencies included in the analysis and the associated response rate.

Table 4
Local Agencies Surveyed

<i>Agency Type</i>	<i>Population</i>	<i>Sample</i>	<i>Responses</i>	<i>Response Rate</i>
Campus Police	2,225	174	21	12.1%
Emergency	6,879	543	94	17.3%
Fire (paid and volunteer)	29,294	2,472	433	17.5%
Municipal Police	10,307	968	288	29.8%
County Sheriff	3,132	296	81	27.4%
Total	51,837	4,453	917	20.6%

To estimate the nationwide LMR value for local public safety agencies, an average value was calculated for each stratification category. Each average was multiplied by the number of agencies in the respective category. The sum of the category values produced the overall nationwide local value. The statistical sampling method and resulting response rate produced a 97.5 percent confidence level for the estimated LMR replacement value for local public safety agencies.

2. RESULTS

2.1 Results of Replacement Value Estimation

Based on review of the survey results, the overall replacement value of LMR communications equipment installed and in use in the United States by local, state, and federal agencies with public safety responsibilities is estimated to be \$18.3 billion. Table 5 provides a breakdown of the estimated LMR replacement values by level of government.

Table 5
LMR Replacement Value

Local	\$ 15.4 billion
State	\$ 1.7 billion
Federal	\$ 1.2 billion
Total	\$ 18.3 billion

2.2 Other Results

The information collected regarding public safety LMR equipment is informative in its own right, independent of its use in determining the replacement cost estimates. The survey results provide a rich set of data regarding the inventories of radio equipment held by local and state public safety agencies. The characterization of this data, which is the subject of a companion analysis document, should provide numerous insights into patterns and trends related to public safety LMR systems.



Spectrum Analysis Program Plan Update

Final

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FOREWORD

The Public Safety Wireless Network (PSWN) program is addressing issue areas essential for planning and fostering the implementation of interoperability among public safety wireless networks. These areas include spectrum, funding, technology (including standards), organization, and operations (including security). Through its integrated planning efforts, the PSWN Program Management Office (PMO) develops and executes a range of crosscutting program activities to address each of these issue areas.

The Spectrum Analysis Program Plan (SAPP) serves as a "capstone document" for the spectrum issue area for the PSWN program. The SAPP identifies and describes current public safety spectrum issues, and it includes summary descriptions of the activities sponsored by the PSWN program to help resolve these issues. The SAPP is a "living document" and will be updated periodically to reflect recent spectrum developments affecting public safety and to include the current suite of spectrum-related activities sponsored by the PSWN program.

The SAPP and other elements of the PSWN Program Five-Year Plan summarize key issues for each issue area and describe the program activities that contribute to their resolution. As these issues are resolved, "building blocks" for interoperability are fashioned and the knowledge necessary for establishing a National Implementation Plan for Interoperability (NIPI) emerges. The NIPI will provide guidelines, best practices, and standard approaches for establishing interoperability.

To offer comments regarding the information contained in this document, or to request more information regarding the PSWN program in general, please contact the PSWN PMO at 1-800-565-PSWN. To obtain available publications related to the activities described in this document, or to learn more about the PSWN program, please see the web page at www.pswn.gov.

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1. INTRODUCTION

Radio Frequency (RF) spectrum is an essential resource for any form of wireless communications. Without adequate amounts of appropriate RF spectrum, wireless communications services that meet user requirements cannot be provided. Congested frequencies are common when spectrum resources are not adequate to support established, let alone intensifying, usage patterns. In some instances, systems managers striving to make more efficient use of limited spectrum have been aided by new technologies that enable greater efficiencies. However, the proliferation of commercial wireless services has created an additional pressure point, namely, heightened competition for spectrum.

The use, regulation, and management of spectrum remain critical issues of concern for improved public safety communications. As spectrum reallocations and commercial spectrum auctions have taken place, spectrum requirements for public safety have remained unmet and the spectrum resources available for public safety use have become increasingly fragmented in location. To assist in this matter, the PSWN program is working to further identify and clarify the issues affecting public safety spectrum. The program is also helping to inform the public safety community about the environment, actions, and processes impacting spectrum availability. In addition, the program is supporting activities that aid in identifying and assigning spectrum to the public safety community. The specific issues of concern include—

- The aggregate amount of spectrum allocated for public safety use should be increased to support current and future communications needs.
- Public safety spectrum should be located across a minimum number of frequency bands and these bands should be well suited for supporting public safety requirements.
- Each public safety frequency band should have spectrum designated specifically to support interoperability requirements.
- Affordable technology to support multi-band communications should be more readily available to the public safety community.
- Spectrum management processes should be better understood and should evolve to encourage interoperability and the efficient use of spectrum.
- A strategy to smartly migrate the public safety community to newly allocated public safety bands should be developed.

The SAPP discusses each of these issues and how the PSWN program is helping to resolve these issues. The current spectrum-related activities of the PSWN program are:

- Spectrum Policy and Legislation Analysis
- Spectrum Management Processes Study
- Radio Frequency Propagation Modeling and Simulation
- Other Contributing Activities
 - Public Safety and Radio Spectrum Guide
 - 800 MHz Study
 - Case Studies and Requirements Analysis.

2. BACKGROUND

RF spectrum is a limited resource essential to the operation of all forms of wireless communications. As the number of wireless systems, services, and applications has proliferated, competition for spectrum has intensified. This development has occurred at a time when technological advancements have enabled more efficient use of the same amounts of spectrum. Technological advancements also have spawned new service offerings, such as those that provide data, imagery, and video via wireless links, resulting in additional demand for limited spectrum. To keep pace with these trends, and to better balance competing interests, spectrum management provisions and processes used by the Federal Government have evolved in recent years. The introduction of commercial spectrum auctions, the reallocation of spectrum to support different needs, and the reduction of channel bandwidths to encourage efficiency are among the actions taken by the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA).

In 1993, the United States Congress authorized the FCC to employ competitive bidding procedures to award spectrum licenses. Since being granted this authority, the FCC has conducted over a dozen auctions and has granted in excess of 4,300 licenses in support of over ten different services. The demand for spectrum to support the burgeoning commercial wireless marketplace has, in part, precipitated reductions in spectrum assigned to non-commercial purposes. For instance, both the Omnibus Budget Reconciliation Act of 1993 and the Balanced Budget Act of 1997 (BBA 97) required the transfer of spectrum currently allocated for Federal Government use to the FCC for auction to the private sector. In addition, efforts by both the FCC and the NTIA are leading to channel plans that encourage the more efficient use of spectrum. In the case of the FCC, so-called refarming efforts are leading to narrowband channel plans, with channel bandwidths reduced by 50 percent or more. Similarly, the NTIA has issued a mandate that requires federal systems to conform, in time, to narrowband 12.5 kHz channels.

Pressures to make additional spectrum available for commercial use and to improve the spectral efficiency of non-commercial systems have created an environment of significant and continuing change for managers and users of public safety land mobile radio systems. In addition, the need to address unmet public safety voice and data requirements and to support the integration of more advanced applications, such as imagery and video, has precipitated further action. For instance, in 1995, the FCC and the NTIA established the Public Safety Wireless Advisory Committee (PSWAC) in response to a request from Congress to provide advice and recommendations on specific wireless communications requirements of public safety agencies through the year 2010. The PSWAC final report, which was issued in September 1996, provided a series of recommendations that pertain directly to spectrum requirements for public safety. In doing so, the PSWAC raised several spectrum-related issues that need to be resolved to ensure effective public safety wireless communications.

Recent actions taken by the FCC and the NTIA in response to BBA 97 provisions represent the latest developments in the spectrum arena. The FCC has allocated additional spectrum for public safety purposes while the NTIA has identified additional spectrum for reallocation and subsequent auction by the FCC. The dynamic nature of spectrum issues requires a cogent plan of analysis if public safety needs are to be met.

3. PUBLIC SAFETY SPECTRUM ISSUES

Based on existing PSWAC recommendations and the continuing evaluation of developments and trends, the PSWN program has identified six spectrum-related issues of pressing concern to the public safety community: 1) the aggregate amount of spectrum; 2) the numbers and appropriateness of frequency bands; 3) the availability of interoperability spectrum; 4) the availability of affordable multi-band technology; 5) the processes used to manage spectrum; and 6) the need for a migration strategy to newly allocated spectrum.

3.1 Aggregate Amount of Spectrum

- *The aggregate amount of spectrum allocated for public safety use should be increased to support current and future communications needs.*

The current amount of spectrum allocated for public safety use is insufficient to meet present day voice and data needs. It cannot relieve existing congestion nor can it support interoperability requirements. Additional spectrum is needed to address these shortfalls and to support the deployment of advanced technologies and applications to accommodate the increased use of data, imagery, and video. The need for additional spectrum also stems from enhanced mission requirements due to population growth, demographic changes, and new domestic threats. In recognition of each of these needs, the PSWAC called for 97.5 MHz of additional public safety spectrum. Of this amount, 25 MHz is required to meet current shortfalls, 2.5 MHz is needed for interoperability below 512 MHz, and the remaining 70 MHz is required by 2010.¹

3.2 Number and Appropriateness of Frequency Bands

- *Public safety spectrum should be located across a minimum number of frequency bands and these bands should be appropriate for supporting public safety requirements.*

Currently, public safety spectrum is located in eight discrete portions of the radio spectrum. This fragmentation impedes interoperability and joint public safety operations. Separate "spectrum islands" that isolate disciplines and jurisdictions have developed. Furthermore, little consideration is given to the appropriateness of the spectrum allocated for public safety use. Propagation effects that make a particular band better suited for public safety are generally not considered. While migrating to an optimal band may not be realistic, reducing the number to an appropriate few is essential for establishing a manageable complement.

3.3 Interoperability Spectrum

- *Each public safety frequency band should have spectrum designated specifically to support interoperability requirements.*

In executing their missions, public safety agencies require the use of certain types of spectrum for different purposes. Agencies require general-use spectrum for routine, individual

¹ Recent actions taken by the FCC have resulted in the reallocation of 24 MHz. In general, this spectrum will not be available for use until 2006 and, in some areas of the country, a date certain for availability may never be established. Notwithstanding these considerations, the newly allocated 24 MHz is a first step toward meeting the PSWAC recommendations.

use. They also require interoperability spectrum to support multi-disciplined, multi-jurisdictional operations. These may take place on a day-to-day or mutual-aid basis, or in support of specialized task forces. To date, insufficient spectrum has been dedicated to meet interoperability requirements. In recent years, a limited number of public safety channels have been set aside for interoperability. While an improvement, these channels do not provide sufficient capacity and only support interoperability among users operating in specific bands.

3.4 Affordable Multi-band Technology

- *Affordable technology to support multi-band communications should be more readily available to the public safety community.*

Public safety agencies will be operating in several bands for some time. The most hopeful scenarios for band consolidation still result in public safety operations in two or three distinct bands. System architectures and equipment that support multi-band communications are essential if interoperability is to be routinely achieved among users operating in different bands. The development of affordable technology that supports this need is essential. Vendors should take note of this market segment and should be encouraged to offer competitive options. Demonstrations and pilot projects should highlight such technology.

3.5 Spectrum Management Processes

- *Spectrum management processes should be better understood and should evolve to encourage interoperability and the efficient use of spectrum.*

The processes by which spectrum is allocated, assigned, and administered for public safety use can appear complex to most system managers and users. Different federal agencies are responsible for spectrum management for public safety—the FCC for local and state entities and the NTIA for federal agencies. The FCC uses frequency coordinators to assist with its administrative responsibilities while the NTIA relies on a well-defined committee structure. The regulations and procedures used by the FCC and the NTIA are not always well understood and have not necessarily been designed to encourage and enable interoperability.

3.6 Migration Strategy

- *A strategy to smartly migrate the public safety community to newly allocated public safety bands should be developed.*

As public safety spectrum issues are resolved and additional, appropriate spectrum is made available for general use and interoperability purposes, the public safety community must take care to migrate its operations in a thoughtful manner. Ad hoc, short-term actions and uncoordinated regional efforts could result in a transformed spectrum environment that is as problematic as the current one (if not more so). Thorough national planning that connects to public safety operations and that integrates local, regional, and nationwide efforts is necessary for establishing a strategy for migration. On-going evaluations of implementation efforts relative to this strategy will also be essential, to ensure that development efforts are consistent with plans.

4. PLAN OF ACTION FOR SPECTRUM ISSUES

The PSWN program is pursuing a set of activities to address current public safety spectrum issues. These activities are designed to contribute to the resolution of the current issues so that spectrum-related impediments to achieving the vision of the PSWN are reduced significantly. In this way, a building block for interoperability evolves, as the spectrum environment becomes more amenable to the needs of the public safety community. In determining and performing the program's suite of spectrum-related activities, the PSWN Program Management Office (PMO) employs a three-part strategic framework that combines process, execution, and management strategies to achieve a balanced, integrated set of activities. These activities approach the spectrum issues from a number of perspectives to address the interwoven array of policy, legislative, managerial, and technical factors that are responsible for the current public safety spectrum environment.

As a part of its annual planning process, the PSWN PMO evaluates its spectrum-related efforts and determines the baseline of activities for the upcoming year. Currently the program is pursuing three efforts focused specifically on spectrum and other contributing activities that provide significant spectrum-related insights. These activities are listed in Table 4-1. Each activity makes contributions to resolving multiple public safety spectrum issues. Table 4-1 makes reference to these issues using the corresponding subsection numbers from Section 3. An "X" is placed in the appropriate cell of Table 4-1 to indicate that a particular activity is helping to address a particular issue. For example, the RF propagation modeling and simulation activity assists with resolving issues related to the number and appropriateness of frequency bands (3.2), the efficacy of multi-band technology (3.4), and the need for a migration strategy (3.6).

Table 4-1
Summary PSWN Program Plan of Action for Addressing Spectrum Issues

PSWN PROGRAM ACTIVITIES	PUBLIC SAFETY SPECTRUM ISSUES					
	3.1	3.2	3.3	3.4	3.5	3.6
<i>Spectrum-Focused Activities:</i>						
- Spectrum Policy and Legislation Analysis	X	X	X		X	X
- Spectrum Management Processes Study			X		X	X
- Radio Frequency Propagation Modeling and Simulation		X		X		X
<i>Other Contributing Activities:</i>						
- 800 MHz Study		X	X		X	
- Case Studies and Requirements Analysis		X		X		X

The activities listed in Table 4-1 are described in summary form in the sections that follow. Detailed descriptions of these and other program activities are contained in the PSWN Program Five-Year Plan.

5. SPECTRUM POLICY AND LEGISLATION ANALYSIS

The purpose of this activity is to understand, monitor, and assess the trends and implications of spectrum policy and legislation as they relate to resolving public safety spectrum issues. This activity consists of three tasks:

1. **The characterization of the current policy and legislative framework for public safety spectrum allocation, regulation, and management.** The high-level processes governing public spectrum allocation, regulation, and management are investigated and documented to provide a comprehensive overview of responsible organizations and players (e.g., the FCC, the NTIA, Congress, frequency coordinators). This information is maintained in the PSWN program's *Radio Spectrum and Legislative Issues Report*. In addition, the FCC's spectrum auctions are monitored and reported upon to document spectrum management processes that apply to the commercial sector. This information is maintained in the PSWN program's *Commercial Spectrum Auctions Report*. This report briefs the public safety community on current events surrounding spectrum auctions and serves as a catalyst for further discussion of the effect that commercial spectrum use has on the public safety community.
2. **The education of the public safety community regarding recent spectrum policy and legislative developments.** The spectrum policy and legislative environment is dynamic and needs to be monitored routinely for interested parties to remain current and informed. Toward this end, research is conducted on a regular basis to ensure that the PSWN program and the public safety community, in general, are kept abreast of pertinent developments. This effort is designed to be broad in scope. The Congress, the FCC, and the NTIA, as the primary organizations responsible for spectrum regulations, are the principal subjects of interest. However, other relevant organizations, such as local and state governments, industry, and public safety groups, are monitored routinely. This information is published in the PSWN program's *Monthly Spectrum Policy and Legislative Report*.
3. **The research and reporting necessary to allow intelligent, strategic contributions to the deliberative processes governing the development of spectrum regulations and policy.** From time to time, the PSWN program's sponsoring organization, the Federal Law Enforcement Wireless Users Group (FLEWUG), participates in processes that help determine spectrum regulations. PSWN program activities directly or indirectly contribute to these efforts by providing the necessary research, insight, and expertise to allow the FLEWUG or other public safety entities to strategically engage such processes. Of particular note are comments and reply comments filed in response to FCC Notices of Proposed Rulemakings (NPRM) that pertain to public safety issues. Comments and reply comments are developed by integrated teams, which draw capabilities and expertise from across the PSWN program. Two recent examples are the *FLEWUG Comments and Reply Comments to the Second NPRM for Public Safety* (WT Docket No. 96-86). The PSWN program also participates in efforts to educate policy makers, legislators, and other government officials about important spectrum issues. A recent example is the *Public Safety and Radio Spectrum Guide*, developed for distribution to Congress and the National League of Cities, among others.

6. SPECTRUM MANAGEMENT PROCESSES STUDY

There is a two-fold purpose to this activity. The first is to develop detailed educational tools regarding the processes governing the assignment, allocation, and administration of public safety spectrum. The second stage is to evaluate ways in which these processes advance or frustrate interoperability and other common goals. This activity consists of three tasks:

1. **Documenting the spectrum allocation, assignment, and administration processes for the local and state public safety communities.** At the local and state levels, frequency administration and assignment is primarily the responsibility of the FCC. Through this effort, the roles and responsibilities of the FCC's public safety office (the Wireless Telecommunication Bureau's Private Wireless and Public Safety Division) and the associated processes for obtaining spectrum are studied. The processes evaluated include the completion of FCC forms; interactions with frequency coordinators; shared-use procedures; and rules and regulations associated with the application and frequency licensing processes, including regulations resulting from refarming proceedings and the National Public Safety Planning Advisory Committee (NPSPAC). The roles of frequency coordinators in spectrum assignment and licensing, their procedures for obtaining frequencies, and their interface with the user community are also assessed and documented. The information developed under this task is contained in the *Local/State Public Safety Spectrum Management Processes Report*.
2. **Documenting the spectrum allocation, assignment, and administration processes for the federal public safety community.** At the federal level, frequency administration and assignment is primarily the responsibility of the NTIA. Through this effort, the roles and responsibilities of various NTIA-supporting entities, such as the Interdepartment Radio Advisory Committee, the Spectrum Planning and Policy Advisory Committee, and the Federal Wireless Policy Committee, are studied. The influence of other federal entities, such as the Office of Management and Budget and the National Institute of Standards and Technology, on NTIA spectrum management processes is assessed as well. This task also involves developing a list of federal agencies with public safety responsibilities, a compilation of the mission statements of these agencies, and illustrations that depict general spectrum assignments made to these agencies. The information developed under this task is contained in the *Federal Public Safety Spectrum Management Processes Report*.
3. **Comparing and contrasting these two distinct sets of processes.** This task seeks to assess the relative merits and shortfalls of the current spectrum management processes; compare and contrast the management processes of local/state and federal public safety spectrum; and provide observations and findings regarding modifications to the existing spectrum management processes. The results of this task are useful in facilitating a dialogue within the public safety community, as well as between this community and the organizations that administer and assign public safety frequencies. Such a dialogue ensures that the process of administering and assigning frequency for public safety is consistent with end-user requirements, such as interoperability, and promotes the efficient and effective use of spectrum. The information developed under this task is contained in the *Public Safety Spectrum Management Processes Comparison Report*.

7. RADIO FREQUENCY PROPAGATION MODELING AND SIMULATION

The purpose of this activity is to develop a complete characterization of public safety radio spectrum bands by comparing propagation and other characteristics in a number of different operating environments. This activity involves computer-based analysis, modeling, and simulation to evaluate the performance of different bands of radio spectrum in varying public safety environments. The information generated by this activity is contained in the PSWN program's *Land Mobile Radio Propagation Analysis Report* as well as in various analysis documents generated at the PSWN program's Technical Resource Center.

Radio frequency propagation modeling and simulation is essential to determining frequency bands that are more appropriate for public safety use. It can be used to reveal the performance implications of certain spectrum policy and legislative developments (e.g., the implications of another frequency band for public safety operations). It also can be an aid in system design and procurement decisions (e.g., the number and locations of sites).

Propagation analyses are conducted using industry-standard models and simulations. For example, the Land Mobile Radio Section (TR8) of the Telecommunications Industry Association (TIA) provides an important reference for selecting wireless prediction models for the land mobile radio environment. Recently, the Compatibility Working Group (WG8.8) within TR8 published a report that describes industry-accepted practices, including recommendations for radio propagation modeling standards and algorithms. This report has progressed to a TIA Subcommittee, TR8.18, to be developed as a standard. Even as final standards, the models merely predict effects and might require verification through actual testing.

The primary outcome of the radio spectrum modeling and simulation activity is a compendium of analysis results that describes key characteristics affecting radio propagation and demonstrates the relevance of these characteristics within each of the public safety frequency bands (low-band VHF, high-band VHF, low-band UHF, and 800 MHz). Key radio propagation characteristics that must be considered across each of these bands include—

- Terrain
- Building penetration
- Tunnels
- Foliage type and density
- Climate
- Surface conductivity.

Numerous path-loss models exist; some are analytical approaches and others are based on empirical data. Each model must be considered for standards compliance, as well as level of fidelity and applicability. It is critical that the models used represent best practices and undergo a verification and validation process.

8. OTHER CONTRIBUTING ACTIVITIES

In addition to directed spectrum efforts, other PSWN program activities contribute to the resolution of public safety spectrum issues. Two notable such efforts are the PSWN program's 800 MHz study and its regional case studies and requirements analysis efforts. These are briefly described below:

- **800 MHz Study.** The purpose of this activity is to assess the relative merits of 800 MHz as an operating band for public safety communications and the extent to which 800 MHz systems have affected interoperability among public safety entities at all levels of government. There are about 300 channels within the 800 MHz band available for use by local and state public safety entities. The findings of this study are documented in the *800 MHz Study Report*. The PSWN program's 800 MHz study reveals much about spectrum planning and management as it pertains to 800 MHz frequencies. It also documents common perspectives of system managers and users as to the impact of 800 MHz on public safety operations. It also provides a high-level characterization of propagation effects at 800 MHz, as compared to other public safety bands. The information contained in the *800 MHz Study Report* has assisted the FLEWUG in preparing NPRM comments and has provided starting points for the PSWN program's spectrum management processes study and propagation analyses.
- **Case Studies and Requirements Analysis.** The PSWN program is performing several case studies and requirement analysis activities in different regions of the United States (e.g., Pittsburgh, Washington, DC, San Diego, and the Southwest border). The studies are comprehensive assessments that allow for the development of a thorough understanding of public safety communications environments, including spectrum usage and resource constraints. Public safety agencies and their radio communications systems are profiled. Numerous spectrum-related data are collected, including current assignments and licenses, additional spectrum requirements, usage patterns, incidents of congestion and contention, propagation dead spots, and problems with obtaining additional licenses. For each area under study, near-term improvements and long-term solutions that improve interoperability and result in the more efficient use of spectrum are determined. To do so, extensive use of radio frequency modeling and simulation capabilities is made. System loading analyses are also performed to understand capacity requirements and determine if the throughput of available spectrum is sufficient for design options under consideration.

9. SUMMARY

The PSWN PMO views spectrum as one of the central issue areas that must be addressed to achieve its vision of seamless, coordinated, and integrated public safety communications for the safe, effective, and efficient protection of life and property. Several activities of the PSWN program have been designed to address spectrum issues of pressing importance to the public safety community. Through these activities, the PSWN program hopes to assist with resolving or mitigating these issues. In this way, the PSWN program is striving to fashion an essential building block for interoperability, one that provides a spectrum environment more fully supportive of public safety.

The SAPP is a capstone report that describes the current suite of public safety spectrum issues and the PSWN program activities that are in place to address these issues. These activities approach the spectrum issues from a number of perspectives to address the interwoven array of policy, legislative, managerial, and technical factors that are responsible for the current public safety spectrum environment. The SAPP and other elements of the PSWN Program Five-Year Plan summarize key issues for major issue areas and describe the program activities that contribute to their resolution. The SAPP is updated periodically to reflect recent spectrum developments affecting public safety and to include the current suite of spectrum-related activities sponsored by the PSWN program.